Competency 4.3 **Radiation protection personnel shall demonstrate the ability to trend radiation protection-related information/data.**

1. SUPPORTING KNOWLEDGE AND /OR SKILLS

a. Trend and analyze operations information and discuss its relationship to radiation protection activities.

b. Given a list of performance indicators, determine what type of assessment should be performed and in what areas.

c. Given DOE Order 231.1, *Environment, Safety, and Health Reporting*, discuss the key elements of the Order and provide examples of its application.

d. Discuss the analysis and trending of radiological data available in the DOE Occupational Radiation Exposure Report or the Radiation Exposure Monitoring System (REMS) for the Department and contractor employees (see Website http://www.saic.com:80/home/doe_rad/doe_rad.htm for this information).

2. SUMMARY

Trending Radiation Protection Data

One of the measures of success regarding a radiation protection program (RPP) is performance. To evaluate performance, one needs to measure change. Several means to accomplish this include tracking, trending, posting, counting, examining, and assigning numbers. The method of trending and analyzing combines the graphing of data with evaluation of the results of performance indicators (PIs). DOE Order 210.1, *Performance Indicators and Analysis of Operations Information*, and DOE/EH-0256T (Revision 1), *Radiological Control Manual* (see Chapter 1) note the importance of utilizing PIs to measure/assess and support progress in improving performance and strengthening both DOE and contractor line management control of operations.

DOE Order 210.1 states that a program shall be established to identify, monitor, and analyze data that measure the environment, safety, and health (ES&H) performance of facilities, programs, and organizations. These data are to be used:

- To demonstrate improving or deteriorating performance relative to identified goals.
- In conjunction with a program to analyze and correlate data as a means to support further improvement through the identification of good practices and lessons learned.

Performance Indicators (PIs) should be chosen that will enable radiation protection personnel to assess the impacts of types of work in specific areas to determine if such work is consistent with applicable regulations, the facility radiation protection plan, and ALARA. Such a list might include:

- Number of work hours in a radiological area
- Number of exposed personnel
- Amount of contaminated work space
- Amount of dose
- Type of dose
- Regulatory requirements
- Radiation protection and monitoring equipment performance
- Radwaste generated
- Liquid and airborne radioactivity generated
- Amount and type of skin and clothing contaminations

Contractors for each facility, group of facilities, or site shall review and assess their PIs and other operations information, such as reportable occurrences. Facility managers shall assess their facility operating information for trends and indications of deteriorating or improving conditions and for identification of lessons learned and good practices that should be used in their facility to prevent occurrences or to improve safety and/or operations.

Radiological doses and events at a facility can be plotted and compared with doses/events at similar facilities, used to identify increasing or decreasing trends within a facility, and can be normalized relative to the amount and types of work being performed. Cases of greater doses than expected are examined with respect to:

- The radiation work permit (RWP)
- Personnel protection
- Wearing and testing of respirators
- Equipment failure due to deterioration and wear
- Work duration in specific areas
- Protection from nonradioactive hazards

DOE-STD-1048-92, *DOE Performance Indicator Guidance Document,* provides trends and analyses of operational data that is useful to both DOE and its contractors. The PIs delineated in this document satisfy the minimum reporting requirements for each facility. For some facilities, certain information may not be applicable and, therefore, need not be reported. However, the report should so indicate this fact. It is also expected that DOE line management may request the reporting of additional PIs that they may determine to be relevant to their facilities. Each level of DOE line management shall adopt trending and analysis of PIs and other ongoing operations information, such as reportable occurances, at all levels of operations to provide ongoing feedback to operators, support personnel, and managers regarding the condition and performance of their operations with the intent of identifying deficiencies/good practices and opportunities for improvement in safety and performance.

It is important to recognize the diverse nature of the types, missions, and staffing levels of the facilities participating in the DOE PI Program. Because of these differences, direct comparison of the facilities and their PI values is not appropriate and may lead to erroneous, or suspect, judgements regarding performance. It should also be kept in mind that the absence of a facility or group of facilities from the list of top contributors does not necessarily imply that performance is either acceptable or unacceptable. Assessments of this nature and conclusions reached on adequacy of performance must be based on evaluation of all the relevant operational information, and these assessments are the responsibility of line DOE program, field, and contractor management.

The PI report's purpose is to establish a tiered system, progressively detailed, with traceability to contractor performance. Reports are the primary mechanism for conveying PI information, associated evaluations of trends, and pertinent operational information. A consistent format is used to provide focus and organization/structure, which helps the reader evaluate the PI information in the proper context of operations. A PI report contains a management summary, overview trend graphs, discussion of each PI, and a list of facilities covered by the report. Field Offices may request a PI report waiver for contractors under their cognizance with PI programs in place, which are sufficiently comprehensive and mature.

The trending and analysis methodology couples graphing of data with evaluation of the results, factoring in relevant operational information to assist with evaluation of the implications of the performance trends (both individually and collectively) from a management perspective. A control chart is an X-Y graph depicting trends over time, which shows the total number of events for each time period of interest. This provides a measure for monitoring changes in the PI. Control limits are the bounds within which the value is expected to occur, barring any "special cause" influences. A data point falling outside control limits or any obvious long-term patterns (e.g., consistently above or below center, consistently rising or falling within the control limits) indicates a significant change to the system. Examples of DOE PIs are as follows:

1.0 Personnel Safety
- 1.1 Collective Radiation Dose
- 1.2 Skin/Clothing Contaminations
- 1.3 Internal Contaminations
- 1.4 Radioactive/Hazardous Materials Overexposures
- 1.5 Lost Work Day
- 1.6 Recordable Illness/Injury Rate

2.0 Operational Incidents
- 2.1 Unplanned Safety Function Actuations
- 2.2 Violations of Operating Procedures
- 2.3 Unplanned Shutdowns
- 2.4 Emergencies and Unusual Occurrences
- 2.5 Substance Abuse

3.0 Waste Generation and Discharges
- 3.1 Radionuclide Effluent
- 3.2 Hazardous Substance/Regulated Pollutant Effluent
- 3.3 Environmental Incidents
- 3.4 Solid Low-Level Radioactive and/or Hazardous Waste Generated

4.0 Program Compliance and Issues
- 4.1 DOE Audit Issues
- 4.2 External Organization Issues
- 4.3 Occupational Safety and Health Noncompliance
- 4.4 Corrective Maintenance Backlog
- 4.5 Preventative Maintenance Overdue
- 4.6 Occurrence Reports with Open Corrective Actions

***Radiological Control Manual* Suggested Performance Indicators**

DOE-STD-1048-92, gives specific guidance on the use of PIs in the ALARA program assessment process. Goals for individual and collective doses should be established and actual doses received should be tracked to improve the performance of nonroutine and high-exposure radiological tasks. Line management should document the goals, their status, and the facility's performance. At least annually, a formal summary of performance related to efforts in dose reduction and contamination minimization and in achieving the site's or facility's radiological goals should be given to senior management in a ALARA report. This information can then be used as feedback into the prejob and postjob briefings.

The radiological PIs following are suggested by the *Radiological Control Manual* as tools to assist facility management in focusing priorities to establish excellence in radiological control. Following, Table 1 provides indicators which can be used to conduct a more detailed analysis of radiological performance.

- Collective Dose (person-rem): This goal should be based upon planned activities and historical performance. For those sites that have neutron radiation, a goal for collective neutron dose should also be established.
- Skin and Personal Clothing Contamination Occurrences (number): Personnel contaminations may indicate a breakdown of controls intended to prevent the spread of contamination.
- Intakes of Radioactive Material (number): Personnel intakes of radioactive material should be minimized and management should focus attention on any failure of the controls that results in intakes.
- Contaminated Area Within Buildings (square feet): Operating with a smaller contaminated area results in less radioactive waste, fewer personnel contaminations, and improved productivity. The reduction of existing contaminated areas needs to be balanced by the recognition that this generates radioactive waste. Goals for both should be correlated.

- Radioactive Waste (cubic feet): Minimizing the generation of radioactive waste reduces the environmental impact of DOE operations; helps reduce personnel exposure and reduces costs associated with handling, packaging, and disposal.
- Liquid and Airborne Radioactivity Released (curies): Minimizing effluents reduces the environmental impact of DOE operations and reduces the costs associated with remediation.

Table 1-1 of the *Radiological Control Manual* lists potential PIs for radiological performance. These indicators allow one facility to compare its performance with other DOE facilities.

Table 1 Suggested Radiological Performance Indicators

Exposure control A. Collective dose in person-rem B. Average worker dose in rem C. Maximum dose to a worker in rem D. Number of unplanned exposures resulting in doses greater than the administrative control level E. Number of dose assessments for lost or damaged dosimeters F. Maximum neutron dose to a worker in rem
Personnel Contamination A. Number of skin and personal clothing contaminations B. Number of contaminated wounds C. Number of facial contaminations
Control of Internal Exposure A. Number of new confirmed depositions B. Number of airborne events C. Number of alarms on airborne monitors (actual and false) D. Number of airborne radioactivity areas E. Area of airborne radioactivity areas in square feet
Control of Contaminated Areas in Operational Areas A. Number of contamination and high contamination areas B. Area of contamination areas in square feet C. Area of high-contamination areas in square feet D. Number of spills
Minimization of Radioactive Waste A. Volume and activity of radioactive waste in cubic feet and curies, respectively B. Number of cubic feet not subject to volume reduction by incineration, compaction, or other means
Control of Radioactive Discharges A. Activity of liquid radioactivity discharges in curies B. Activity of airborne-radioactivity discharges in curies

Assessments

Internal audits, inspections, reviews, investigations, and self-assessments make up "assessments" and are a part of the numerous checks and balances needed in an effective radiological control program. The more preparation put into an assessment, the more effective it is. There are two basic types of assessments: unstructured and structured. Unstructured reviews, or general assessments, do not concentrate on one specific area. These reviews can be accomplished, for example, by conducting a general walkthrough or accompanying workers on routine activities. A structured assessment involves looking specifically at one issue and reviewing it from every angle. Two traditional methods within the structured inspection are the vertical and horizontal review.

A vertical review is the assessment of a narrow subject area in great detail (e.g., assessing the radiological control organization from top to bottom). A horizontal review is the assessment of a broad range of related subjects in generally less detail (e.g., assessing radiological protection across all organizations at a nuclear facility).

DOE Order 231.1, *Environment, Safety and Health Reporting*	
Purpose	Ensure collection and reporting of required ES&H information, and information that is essential for DOE operations. The reports listed under this Order are to be used in accordance with DOE M 231.1-1, *Environment, Safety and Health Reporting Manual*, which specifies in detail the reports that shall be filed, organizations responsible for filing the reports, the recipients of the reports, how reports shall be prepared, and the time schedules in which the reports shall be filed or submitted.
Scope	DOE and DOE contract elements
Requirements/ Key Words	Heads of DOE Elements Should report interim exposure data reporting in accordance with DOE M 231.1-1. Report work-related ionizing radiation exposure data pertaining to an individual who visits a DOE or contractor site or facility to the Radiation Records Repository, to the individual's employer, and to that individual. Should report annual exposure data summaries to the Radiation Records Repository for each monitored person. Should submit radiological exposure reports to individuals. Assistant Secretary for Environment, Safety and Health Must inform the cognizant Secretarial Officer when a Headquarters employee's occupational ionizing radiation exposure for a given period approaches 70% of an administrative or regulatory limit. Must approve the use of alternative media for submitting information to the Radiation Records Repository as required by this Order.

Detailed instructions for preparing occupational exposure data summaries are given in Appendix G of DOE M 231.1-1 which can be found on the following web site:

http://www.explorer.doe.gov:1776/htmls/alldirectives.html

DOE Radiation Exposure Monitory System (REMS)

NOTE: The REMS for DOE and contractor employees has been moved to the following website:

http://rems.eh.doe.gov/

DOE sites are required to submit the results of the occupational radiation exposure monitoring to Headquarters on an annual basis in accordance with DOE O 231.1-1. The format and content of the reports are specified in DOE M 231.1-1, Appendix G. There are several modes of accessing the REMS data: 1) published reports (annual report), 2) webpage, or 3) REMS Query Software.

The occupational radiation exposure information page on the Web is intended to provide the latest available information on radiation exposure to the workforce at DOE facilities, and serve as a central location for the dissemination of information concerning reporting requirements. Dose records can be found for all individuals monitored at DOE facilities including DOE personnel, contractors, and visitors; this does not include exposures to the public. Dose records are available from 1987 to the present.

When querying the REMS data, information can be displayed by:

- Total dose
- Number of individuals
- Average measurable dose
- Dose distribution (currently not available)

Information can be sorted by selecting the following data ranges from scrollable lists:

- Year
- Operations office
- Site
- Reporting organization
- Facility type
- Labor category
- Occupation
- Monitoring status

Users of the REMS information should be alert to some of the limitations of the data presented on the webpage:

- Data is subject to change when updates are received.
- Dose distribution reporting methods prior to 1987 resulted in up to 20% overestimation of collected dose.
- Data prior to 1987 is not included in the webpage query tool.
- While all sites have achieved compliance with DOE Laboratory Accreditation Program (DOELAP), which standardizes the quality of dosimetry measurement, there are still differences in the dosimeters used that can contribute to differences in the collective dose from site to site.
- Due to the change in the internal dose calculation methodology in 1993, the total effective dose equivalent (TEDE) is not applicable for 1987 and 1988 data using the webpage query tool, and is shown as zero for these years.
- Definitions of each labor category are subject to interpretation by the reporting organization, and up to 20% of the occupations are listed as unknown or miscellaneous.
- There are changes in the way each site reports the facility and organization code.
- Dose information for the overall DOE complex presented in the annual report may differ from other reports because of the exclusion of the Schenectady and Pittsburgh Naval Reactor facility.

3. SELF-STUDY SCENARIOS/ACTIVITIES AND SOLUTIONS

Scenario 1

A worker from a DOE contractor facility detected contamination on his hands while exiting a work area where plutonium-239 and uranium-235 were being used. A radiological control technician (RCT) investigated and found five other workers who were involved in the same work that day. One of the workers had already gone home, so after informing his supervisor, the RCT contacted him there. The worker was found to have 2,000 dpm on the sole of his personal shoe and 700 dpm on the seat of his pants.

Scenario 2

In another incident, a visiting scientist performing research at a cyclotron facility left in a hurry one day to catch a flight home (a distance of 2,000 miles) to enjoy a four-day weekend with his family. An RCT used this opportunity to do a thorough survey of the laboratory in which the researcher worked. He detected 500,000 dpm/100 cm^2 of carbon-14 contamination on the floor (presumably caused by a leaking target). The RCT immediately notified his supervisor, who contacted the researcher at his home and informed him of the RCT's findings. Subsequent investigations and surveys found 200,000 dpm/100 cm^2 on the sole of the researcher's right personal shoe and a trail of contamination leading from the facility to the researcher's home.

Using the performance indicator data supplied below, along with the information supplied in the scenarios, answer the following.

1. What trend(s) do these incidents indicate?

2. Which performance indicator(s) should give insight into the problem?

3. Discuss some corrective actions to address the problems identified.

4. What are your conclusions about these incidents?

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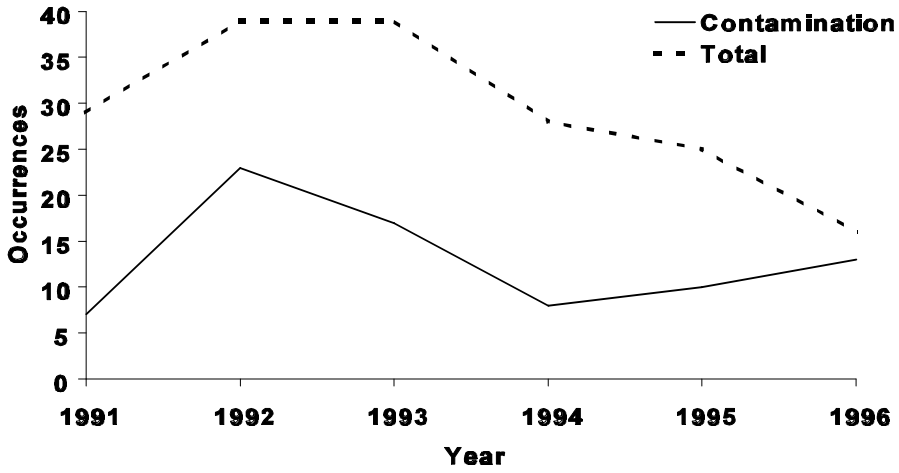
Reportable Facility Occurrences
1991-1996



Scenario 3

Yearly data comparisons are one of the easiest ways to recognize trends. The following table depicts the collective dose equivalent (person-rem) for monitored DOE/DOE contractor employees and visitors by field organization for the years 1982-1991.

Using the table, answer the following:

- What was the collective dose equivalent received by employees and visitors in 1985?
- In 1991?
- How do the figures compare?
- What trend is occurring?
- What are some possible reasons for the trend?

Collective Dose Equivalent (Person-Rem) for Monitored DOE/DOE Contractor Employees and Visitors by Field Organizations for the Years 1982-1991

Field Organization	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
A	1,112	1,190	1,423	1,344	979	483	556	432	363	389
B	587	623	615	502	408	348	310	240	214	173
C	363	353	441	420	620	318	253	336	366	177
D	29	25	24	34	65	8	13	6	7	3
E	401	371	419	353	587	517	360	218	173	172
F	194	220	180	180	109	78	86	85	23	84
G	2,272	2,458	2,399	2,548	2,321	2,477	654	619	353	275
H	1,173	1,142	1,315	1,556	1,407	880	654	412	769	902
I	289	267	195	187	99	78	74	82	64	77
J	1,310	1,293	1,283	1,394	1,498	945	887	804	753	459
K	147	217	130	165	167	220	81	140	240	233
Total	**7,877**	**8,159**	**8,424**	**8,683**	**8,260**	**6,352**	**3,928**	**3,374**	**3,325**	**2,944**

Scenario 4

Which facility exhibited the most dramatic decrease in collective doses and what are some possible reasons for the decrease?

Answers to Scenarios

Scenarios 1 and 2, Solution
(Any reasonable paraphrase of the following is acceptable.)

The facility's occurrence reports were reviewed and it was noticed that although the total number of reportable events appeared to be decreasing, the events of loss of control of radiological material/spread of contamination had been increasing. Trends could be found in routine area surveys, numbers of contamination events, and instrument or target failures.

The facility manager, facility division director, and group leaders met and discussed corrective actions, including a standdown of programmatic activities. They determined that complacency to radiological hazards and failure to enforce radiological controls were contributing causes to recent incidents. During the standdown, the facility manager and group leaders informed relevant personnel that they would be held accountable for their actions.

These events underscore the need for enforcing radiological controls at the worker level. Complacency to radiological contamination must be avoided through the development of effective controls.

10 CFR Part 835, *Occupational Radiation Protection*, contains specific requirements regarding the need for radiological control measures. The *Radiological Control Manual* identifies controls and techniques to preclude contamination. It also provides guidance in the establishment and maintenance of control programs.

Suggested corrective actions include: re-training of individuals, evaluation of relevant procedures, evaluation of adequacy of engineered and administrative controls, and the adequacy of monitoring requirements.

Scenario 3, Solution
(Any reasonable paraphrase of the following is acceptable.)

- 8,683 person-rem
- 2,944 person-rem
- The 1991 figure is significantly less (66% reduction)
- Doses received by DOE/DOE contractor employees and visitors have decreased dramatically in more recent years.

- The majority of the decrease is attributable to the reduction of production tasks at DOE facilities and an increased emphasis on ALARA programs.

Scenario 4, Solution
(Any reasonable paraphrase of the following is acceptable.)

Facility G exhibited the most dramatic decrease in collective doses. Some possible reasons for the decrease could be:

- facility shutdowns
- changes in type of work performed
- increased safety initiatives
- increased emphasis on ALARA

4. SUGGESTED ADDITIONAL READINGS AND/OR COURSES

Readings

- DOE Order 210.1, *Performance Indicators Program* (supersedes DOE Order 5480.26).
- DOE-STD-1048-92*, DOE Performance Indicator Guidance Document.*
- DOE/EH-0256T (Revision 1), *Radiological Control Manual*.

Courses

- DOE/EH-0450, *Radiological Assessors Training (for Auditors and Inspectors) Applied Radiological Control Applied Health Physics* -- Oak Ridge Institute for Science and Education.
- *Radiation Protection Functional Area Qualification Standard Training* -- GTS Duratek.